

fires show that the percentages decrease from the beginning as the wet-bulb depression rises. This is exactly what would be expected. With the class B fires the percentages rise gradually as the depression rises until a depression of 16° is reached, and then there is a gradual decline, except at depressions above 25°, where the number of fires is too few to give reliable percentages. Under class C the percentages gradually increase until a depression of 21° is reached, and then there is a slight decline, disregarding the last two figures. With class D fires the peak is reached at a depression of 23°. Under class E and class F the number of fires that occurred was really too small relatively to give reliable percentages; however, the figures given indicate that the highest percentages in these two classes were reached at a depression of about 25°. The interesting feature is that the peak on the percentage scale of each class of fires falls at a higher point on the wet-bulb depression scale as the size classifications increase. This indicates that, regardless of wind velocity, which is the big factor in fire spread, fires increase in size as the wet-bulb depression increases. The percentage figures on fires under classes A, B, and C, as shown in Table 1, are presented in graphic form in Figure 2. In Figure 2 the curves drawn for the A, B, and C fires are smoothed out to take care of the inconsistencies shown in the table. A tabulation of let us say 10,000 fires would undoubtedly smooth out the percentage curves so that they would probably appear about like the smoothed curves shown in Figure 2.

It is believed that use of the wet-bulb depression as a criterion of forest fire hazard is a real step forward in fire-weather work. The idea was given a trial during the season of 1931 and found to work very satisfactorily. In the Lake States district an effort is made to predict the maximum temperature and the minimum relative humidity for the ensuing day. Therefore a chart such

as the one shown here should be valuable aid to the forest ranger as well as to the meteorologist, for it enables one to assign about the proper weight to both the temperature and the relative humidity that is expected, or that may be prevailing, in estimating the hazard. In working out the wet-bulb depression idea other methods for determining the combined effects of temperature and relative humidity on fire hazard were tried and eliminated, either because they were not of much value or because they were impractical for daily use.

TABLE 1

Wet-bulb depression	A 0 to 1 acre		B 2 to 10 acres		C 11 to 100 acres		D 101 to 500 acres		E 501 to 1,000 acres		F 1,001 acres and over		Total number of fires
	Fires	Per cent	Fires	Per cent	Fires	Per cent	Fires	Per cent	Fires	Per cent	Fires	Per cent	
3.....	5	71	2	29	0	0	0	0	0	0	0	0	7
4.....	15	60	6	24	4	16	0	0	0	0	0	0	25
5.....	19	48	12	30	8	20	1	2	0	0	0	0	40
6.....	22	38	18	31	16	27	1	2	1	2	0	0	58
7.....	21	30	26	37	19	27	3	4	1	1	1	1	71
8.....	37	31	32	28	28	25	11	10	3	3	3	3	114
9.....	42	29	44	31	40	28	13	9	2	1	3	2	144
10.....	48	30	53	33	42	26	14	9	2	1	2	1	161
11.....	60	32	61	33	48	26	12	7	2	1	2	1	185
12.....	57	30	63	33	50	27	13	7	4	2	1	1	188
13.....	60	28	76	35	58	27	16	7	5	2	2	1	217
14.....	68	28	91	38	64	27	10	4	2	1	6	2	241
15.....	85	28	117	38	70	23	18	6	6	2	8	3	304
16.....	68	25	106	39	67	24	20	7	5	2	7	3	273
17.....	61	24	87	34	75	29	24	9	5	2	6	2	258
18.....	60	26	84	36	65	28	15	6	4	2	5	2	233
19.....	46	23	72	36	59	30	13	7	4	2	5	2	199
20.....	43	26	58	34	51	30	13	8	2	1	2	1	169
21.....	25	17	47	33	49	34	11	8	6	4	5	4	143
22.....	23	23	34	34	34	34	5	5	2	2	2	2	100
23.....	18	26	20	28	20	28	11	16	1	1	1	1	71
24.....	12	21	16	28	19	33	6	10	2	4	2	4	57
25.....	3	12	6	26	8	34	3	12	1	4	3	12	24
26.....	2	20	4	40	3	30	1	10	0	0	0	0	10
27.....	1	20	2	40	1	20	1	20	0	0	0	0	5
28.....	0	0	1	33	2	67	0	0	0	0	0	0	3
29.....	0	0	1	50	1	50	0	0	0	0	0	0	2
Total fires....	901		1,139		901		235		60		66		3,302

## A. WAGNER'S "CLIMATOLOGIE DER FREIEN ATMOSPÄRE"

Abstract by J. C. BALLARD

This work, which is Volume I, Part F, of the new Handbuch der Klimatologie, contains a systematic treatment of a large amount of widely scattered upper-air observations. Wherever possible, temperature, humidity, pressure and wind conditions with respect to latitude, longitude, and topographical features have been summarized and discussed. Practically no references to clouds have been made.

A large section of the book deals with North America. This is subdivided as follows: (a) Temperatures found with the aid of kites, captive and limited-height sounding balloons, and airplanes; (b) Sounding balloon flights; (c) Relative humidity; (d) Pressure; (e) Wind.

The part dealing with temperatures contains tables of normals based on the latest available data for the standard levels up to 4 kilometers for Ellendale, N. Dak., Drexel, Nebr., Royal Center, Ind., Washington, D. C., Broken Arrow, Okla., Due West, S. C., and Groesbeck, Tex. Other tables show the free-air temperature distribution with latitude and longitude, vertical temperature gradients, and annual amplitudes. The discussion here, as throughout the book, is concise and confined to the most important features.

Although the sounding balloon data were relatively meager, comparison was made between the St. Louis-Omaha region and the Toronto-Woodstock region. The data from the series of sounding balloon observations

made during the winter of 1927-28 at 12 Weather Bureau stations were published too late to be included in this part, but a few notes have been added at the end of the book with regard to these data.

Smoothed means of the annual march of the relative humidity for altitudes up to 3 and 4 kilometers are given for the seven stations mentioned above.

Mean barometric pressures for various elevations for several stations are given and also a table of pressure gradients for longitude 97° W.

The section on wind contains tables dealing with air displacement, annual march of the wind velocity and direction, and maps showing mean stream lines for the 1, 2, and 3 kilometer levels. In the discussion of these tables important facts are brought out concerning the effect of the Rocky Mountains on the air displacement.

The second section, dealing with Europe, follows a plan of treatment similar to that for North America. Several tables showing temperatures are given, as well as the average temperature and height of the tropopause for several European stations. The sections on relative humidity and barometric pressure however, are not so well provided with data. Mean pressures, for each season and for the year are given for heights up to 16 kilometers for three stations, viz., Lindenberg, München, and Pavia. Considerable wind data are given for regions north of the Alps.

The third section of the work deals with wind distribution in the Mediterranean district. Data are included in the tables of this section for a number of countries, including Italy, the Balkans, Palestine, Turkey, and Algiers.

The region of the Tropics is next taken up and discussed under two headings, viz, temperature and wind.

A table of mean temperatures and lapse rates is given for Batavia, and also a table of the average height and temperature of the tropopause for the various months. A table of mean relative humidities for the wet and dry seasons for Batavia shows large differences between these two seasons.

Monthly means of air displacement are given for Batavia for heights up to 24 kilometers, and are based on several hundred observations. Wind data for other regions include central Africa, Honolulu, Samoa, and Mauritius. Mention is also made of Guam, San Juan, and Barranquilla.

The section relating to the Atlantic Ocean is comparatively short, especially that dealing with temperature, little actual data of which are given. However, the important features are mentioned and a few references given. No tables of wind values are given for the Atlantic Ocean, but mean stream lines are shown for winter and summer for the 1-1.5 kilometer and 4-5 kilometer levels.

A good discussion is given of the temperature and wind distribution over India.

Mean monthly and annual temperatures at Agra are shown for heights up to 20 kilometers. The temperature gradients, and the mean heights and temperatures of the tropopause for the various months have also been computed and are given for this station.

Wind data are given for eight stations for three characteristic months, viz, April, August, and December.

Various temperature tables based on kite and sounding balloon observations are given for the region of Spitzbergen and for the base of the British Antarctic expedition of 1911.

The part dealing with winds in the polar regions includes discussions and tables of data for the east and west coast of Greenland, Iceland, the Arctic Ocean, and the Weddell Sea.

The next section of the work deals with isolated sets of observations in the following countries: Egypt, Australia, New Zealand, Japan, Uruguay, and Russian Turkestan.

The part dealing with Egypt contains a table giving free-air pressures, temperatures, and humidities for Helwan. Upper-air wind directions are given for six stations.

The means of a large number of wind observations are given for Australia and New Zealand, and also mean temperatures based on 13 sounding balloon observations.

The means of several hundred wind observations are given for Tatenos, Japan, and the means of a lesser number for Montevideo and for Tashkent, in Russian Turkestan.

In the last section the author discusses the free-air temperature and pressure in a meridional section of the Northern Hemisphere. A figure has been drawn to represent the temperature and height of the tropopause along a meridian and with the aid of these temperatures the pressures in a meridional section have been computed. From the pressures a table of pressure gradients was computed and the general circulation discussed with reference to this table.

In this connection it was found that equatorially directed pressure gradients—i. e., lower pressure toward the Equator—occur in the following areas: In summer (1) at the surface between 30° and 10° and again between 90° and 70° latitude; (2) from 6 kilometers up to the greatest heights between 10° and 0°; (3) above 16 kilometers from the Pole to 50° to 40°. In winter (1) in the low levels between the horse latitudes and Equator; (2) above 18 kilometers between 10° and 30° latitude, (3) in the region of the Pole.

Relatively large poleward directed pressure gradients were found in winter at heights of 12 to 18 kilometers, between 0° and 10° latitude. Thus at these heights in winter, west winds theoretically can occur near the Equator. Such winds have been observed in the pilot balloon flights of Batavia.

The maxima pressure gradients were found, at the surface, to be between 50° and 60° latitude in summer and between 70° and 80° latitude in winter. In both seasons the maxima are displaced equatorially with increasing height.

## THE COLDER THE AIR THE THINNER THE ICE

By W. J. HUMPHREYS

It is a saying among certain Great Lakes fishermen that ice grows faster in zero (Fahrenheit) weather than it does when the temperature is considerably subzero. This, if true, is one of nature's many pleasing puzzles which it always is a delight to solve. But is it true?

Evidently the rate of thickening of the ice (at the under surface, of course) is proportional to the rate of loss of heat by the water up through the ice cover. Under steady conditions this rate in turn is proportional directly to the thermal conductivity of the ice and the difference in temperature between its upper and under surfaces, and indirectly to the thickness of the ice sheet. In other words, it is proportional to the conductivity of the ice and the temperature gradient through it. Now the conductivity of ice is a constant, nearly, if we neglect, or take into account and average, the effect of air bubbles and other irregularities. Also the temperature at the under surface of the ice is a constant, namely, 32° F., in the case of fresh water. We, therefore, can say that for any given thickness of the ice, the rate of its further

growth, under steady conditions, is directly proportional to the extent to which the temperature of its outer surface is below the freezing point. That is, it is proportional to  $32 - t_s$ , in which  $t_s$  is the temperature, as indicated by a Fahrenheit thermometer, of the upper surface. If, then, this upper surface always had the temperature of the air above it, there would be no occasion to explain the paradox in question, for there would be no paradox. But this relation does not always hold, and in that fact we have the solution of our fisherman's puzzle.

At temperatures around zero Fahrenheit there is not likely to be much fog drifting over the ice from the open water farther out in the lake, and often too at such times there is wind enough to keep the surface of the ice swept clean of snow. On the other hand, when the temperature of the air is considerably lower the "frost smoke," produced by the "steaming" of the open, deep water and remaining unevaporated at the low temperature, well may spread out slowly over the ice and thereby not only decrease the net loss of heat by radiation, as fogs and